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Trade and Fluctuations

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Cross-country GDP growth rate correlations averaged 45 percent among the OECD economies in 1965–90. This paper demonstrates the role of trade in the transmission of economic disturbances across countries, generating a high degree of synchronization in growth rates.

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Summary findings

A look at the data reveals that in OECD countries, economic fluctuations exhibit a high degree of synchronization. In 1965–90, cross-country contemporaneous GDP growth correlations averaged 45 percent. This suggests that a central element of any theory of economic fluctuations should be an explanation of how economic disturbances are transmitted across countries. But the large body of recent research that emphasizes productivity shocks as the source of fluctuations has been unsuccessful in this regard. The reason, argue Kraay and Ventura, is that these models have not properly addressed the role that commodity trade plays in economic fluctuations.

Kraay and Ventura develop a stylized model of commodity trade and economic fluctuations that shows how economic disturbances are positively transmitted internationally, generating the high degree of synchronization in GDP growth rates of OECD countries from 1965–90. The positive transmission mechanism is simple: international booms increase the prices of labor-intensive commodities, raising domestic wages and stimulating employment and output at home. This is the “wage effect.” Empirically, this wage effect seems to be large enough to dominate the “interest rate effect” — that international booms also increase world interest rates, induce agents to invest abroad, reducing the domestic capital stock and output. While smaller than the wage effect, the negative transmission by way of the

interest rate effect generates predictions that are consistent with existing evidence on current account fluctuations in the OECD. In particular, the model correctly predicts that capital should flow into those countries that experience a boom (relative to the rest of the world), producing current account deficits.

The 1980s and early 1990s have brought about rapid financial liberalization. To analyze the implications for the transmission mechanism, Kraay and Ventura also present a model of trade and fluctuations in which agents in some countries are allowed to trade financial assets across borders. This model yields the counterintuitive prediction that the current process of financial integration should lead to a lower degree of synchronization of economic fluctuations. While the wage and interest rate effects still operate in the second model, financial integration creates an additional transmission channel: the “risk-sharing effect.” Since the domestic economy shares in the good times experienced in the rest of the world through financial risk-sharing agreements, international booms raise income at home and, provided leisure is a normal good, discourage employment and reduce output. This is a mechanism of negative transmission and reduces the predicted cross-country GDP growth correlations. Although theoretically interesting, evidence from the U.S. states suggests that this risk-sharing effect is small relative to the wage effect.

This paper — a product of the Macroeconomics and Growth Division, Policy Research Department — is part of a larger effort in the department to study international macroeconomics. Copies of the paper are available free from the World Bank, 1818 H Street NW, Washington, DC 20433. Please contact Rebecca Martin, room N11-059, telephone 202-473-9065, fax 202-522-3518, Internet address rmartin1@worldbank.org. December 1995. (33 pages)

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Trade and Fluctuations

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A casual look at the data reveals that in OECD countries, economic fluctuations exhibit a remarkable degree of synchronization. During the 1965-1990 period, cross-country contemporaneous GDP growth correlations averaged 45%.¹ This fact suggests that a central element of any theory of economic fluctuations should be an explanation of how economic disturbances are transmitted across countries. However, the large body of recent research which emphasizes productivity shocks as the source of fluctuations has been quite unsuccessful in this regard. The reason, this paper argues, is that these models have not properly addressed the role that commodity trade plays in economic fluctuations.²

Figure 1 summarizes the main facts regarding the international transmission of economic disturbances (see also Table 1). On the Y-axis, we plot the correlation of a country's per capita GDP growth rate with the OECD growth rate *minus* the correlation of the country's Solow residual with the OECD residual. We will follow the conventional, although admittedly controversial, practice of interpreting Solow residuals as a measure of productivity shocks. On the X-axis, we have the correlation between a country's current account surplus and the deviation of its GDP growth rate from the OECD average. Two observations or 'stylized facts' emerge from this figure: (1) cross-country GDP growth correlations exceed those of Solow residuals (21 of 24 countries), and (2) domestic growth in excess of OECD growth is associated with current account deficits (17 of 24 countries).³

To understand why Figure 1 poses a problem for existing models, imagine that we generate data by simulating the standard stochastic growth model. Where would we locate this artificial economy in Figure 1? Trivially, if we used a closed-

¹ During this period, within-country one-year autocorrelations averaged only 25%. That is, the contemporaneous OECD average growth rate (excluding the country in question) is a substantially better predictor of a country's growth rate than the previous year growth rate of that same country. See the appendix for a detailed description of the data we use throughout the paper.

² See Backus, Kehoe and Kydland (1993) for an excellent survey of these models and their problems.

³ These are by no means new observations. These facts have been documented previously by Stockman (1990), Backus and Kehoe (1992), Costello (1993), Backus, Kehoe and Kydland (1992, 1993), Stockman and Tesar (1995) and Glick and Rogoff (1995), among others.

economy version of the model, the answer would be 'on the Y-axis and very close to the origin'. In autarkic economies, current accounts are zero by definition and, since only domestic shocks can account for growth fluctuations, the cross-country correlations of growth rates cannot be much higher or lower than the cross-country correlations of the productivity shocks that drive them. More interestingly, if we used the standard open-economy version of the model that allows for foreign investment and/or international lending, the answer to the question above would be 'somewhere in the lower-left quadrant'. In this second class of models, international booms induce capital to leave the domestic economy to take advantage of higher productivity (i.e. interest rates) abroad. This *interest-rate effect* lowers output at home directly by reducing domestic investment and the capital stock, and also indirectly through a reduction in wages and employment. While simulations of these models are roughly consistent with the current account comovements depicted in Figure 1, they produce GDP growth correlations which are typically negative and, in any event, much smaller than those of productivity shocks.⁴

In this paper, we argue that the inability of the standard open-economy stochastic growth model to explain observed GDP growth correlations arises from its inadequate treatment of the link between international commodity prices and domestic wages. Once it is recognized that OECD economies engage in international commodity trade, one should realize that domestic wages depend not only on domestic factor endowments but also on the entire structure of internationally-determined commodity prices. Although international booms still lead to capital outflows through the interest-rate effect, if these booms are also associated with increases in the relative price of labour-intensive commodities, domestic wages, employment and output at home will rise. If this *wage effect* is large enough, it has the potential to explain how international booms are positively transmitted into the domestic economy, despite the contractionary effect of observed capital outflows. To formalize this idea, we develop a highly stylized model of the

⁴ See, for instance, Baxter and Crucini (1993).

world economy in which the factor-price-equalization theorem of international trade holds. Our model is extreme in that domestic wages are completely independent of domestic factor endowments, and only respond to changes in international commodity prices. Despite its simplicity, the model is able to generate a pattern of correlations which is consistent with those in Figure 1.⁵

A key element of our explanation is therefore that international booms (recessions) are associated with increases (reductions) in the relative price of labour-intensive commodities. Figure 2 plots the correlation of commodity price growth rates with world average output growth over the period 1965-1990 (on the Y-axis) against the average labour intensity of that commodity over the same period (on the X-axis) for 28 manufacturing sectors for eight OECD economies. Each data point corresponds to a manufacturing sector, and is identified by its three-digit ISIC code. The upward-sloping relationships that appear in Figure 2 indicate that prices of labour-intensive commodities tend to be procyclical with world average output growth, while prices of capital-intensive commodities tend to be countercyclical. This is exactly the pattern of shocks that underlies our transmission mechanism.

For most of the sample period from which the data in Figures 1 and 2 are drawn, it seems reasonable to assume a low degree of financial integration among OECD countries. Yet the legal and technological obstacles to international trade in financial assets have been reduced dramatically in recent years. It is therefore interesting to investigate the implications of these developments for our transmission mechanism. To do so, we construct a second model of trade and fluctuations in which agents in some countries are allowed to trade in financial assets. An interesting and somewhat unexpected implication of the theory is that financial integration weakens the transmission of global shocks to the domestic economy, and hence reduces the degree of synchronization of business cycles across

⁵ Recent evidence put forward by Trefler (1993) strongly suggests that a conditional version of the factor-price-equalization theorem might be a reasonable description of reality. None of the results of this paper hinge on the difference between the conditional and absolute versions of this theorem.

countries. The reason is simple: If countries are permitted to trade in contingent claims to each other's output, each country's financial portfolio contains a sizable fraction of foreign assets. Since the domestic economy shares in the good times experienced in the rest of the world through these financial risk-sharing agreements, international booms now raise income at home and, provided leisure is a normal good, discourage employment. Ceteris paribus, this *risk-sharing* effect reduces the cross-country correlation of GDP growth rates. Since for most OECD countries financial integration is only a recent phenomenon, we look at data for the U.S. states (which we assume to be a set of financially integrated economies). We find that the correlations between Gross State Product (GSP) and OECD GDP growth exceed those of Solow residuals. This evidence suggests that the risk-sharing effect is empirically small relative to the wage effect.

Our model exhibits some technical features that distinguish it from previous work in the field. First, we consider a world with infinitely many atomistic countries, instead of the standard two-country world. This allows us to eliminate large-country effects and focus on the pure effects of international linkages on the nature of economic fluctuations, while retaining the benefits of using fully specified dynamic general equilibrium models of the world economy. We also depart from standard practice by using continuous-time models instead of the usual discrete-time ones. This allows us to obtain analytical expressions for the statistics of interest, i.e. variances, covariances and correlation coefficients for GDP growth rates and current accounts. Consequently, we perform comparative statics to determine the properties of the model, instead of relying on a particular set of simulations.

The paper is organized as follows. Section 1 develops the basic model of trade and fluctuations. Section 2 shows that this model is consistent with the data. Section 3 considers the effects of financial market integration. Section 4 concludes.

1. A Model of Trade and Fluctuations

In this section, we present a simple model of economic fluctuations that highlights the roles of international trade and foreign investment. To sharpen results, we examine a world in which each country is so small that domestic disturbances do not influence its terms of trade. Moreover, since it turns out that intertemporal considerations have little bearing on the issues discussed here, we abstract from capital accumulation and assume that shocks are permanent (so that the world is never expected to change).

Description

The world consists of a large number of countries, indexed by $j=1,2,\dots,J$. For simplicity, we focus on the limiting case in which $J\rightarrow\infty$. We denote world averages by omitting the country index, and we suppress the time index wherever it is possible to do so. There exist two non-storable commodities referred to as good 1 and 2, which can be traded internationally at no cost. There are three factors of production: labour (n_j), internationally immobile capital (h_j), and internationally mobile capital (k_j). We normalize each country's labor force and population to one. At every point in time, each country receives a unit endowment of each type of capital, which depreciates fully in production.

In each country, there are many firms with free access to the existing production technology. Let q_{1j} and q_{2j} be the production of good 1 and 2, respectively. One unit of good 1 is produced using one unit of labour, i.e. $q_{1j}=n_j$. Good 2 is produced using both types of capital, i.e. $q_{2j}=\pi_j \cdot h_j^{1-\gamma} \cdot k_j^\gamma$. π_j is a

productivity disturbance with dynamics that can be represented by the following diffusion process:

$$\frac{d\pi_j}{\pi_j} = \sigma \cdot d\theta_j \quad (1)$$

The $d\theta_j$ are Wiener increments with $E[d\theta_j]=0$ and $E[d\theta_j^2]=dt$ for any j , and $E[d\theta_j \cdot d\theta_i]=\epsilon^2 \cdot dt$ for any $j \neq i$. This representation implies that country j 's productivity growth has mean zero and a constant instantaneous variance-covariance matrix with all other countries.

Each country contains many identical and infinitely-lived consumers who derive utility from consumption of both goods and leisure. These consumers take prices as given, and decide how to allocate consumption between the two commodities, how much to work and where to invest the unit of mobile capital. Let c_{1j} and c_{2j} denote the quantities consumed of commodities 1 and 2, respectively. All consumers maximize the following utility indicator:

$$E_0 \int_0^{\infty} \ln \left\{ (c_{1j}^\alpha \cdot c_{2j}^{1-\alpha})^{1-\beta} \cdot (1-n_j)^\beta \right\} \cdot e^{-\rho t} \cdot dt \quad (2)$$

where $0 < \alpha, \beta < 1$ and $\rho > 0$. We define a unit of consumption as $c_j = (c_{1j}/\alpha)^\alpha \cdot (c_{2j}/(1-\alpha))^{1-\alpha}$ and normalize commodity prices such that $p_1^\alpha \cdot p_2^{1-\alpha} = 1$. This choice of units will considerably simplify the algebra. Moreover, it turns out that this normalization rule is equivalent to deflating all variables with the ideal consumer price index. Since only relative prices matter, define $p = p_1/p_2$ and then use the normalization rule to rewrite $p_1 = p^{1-\alpha}$ and $p_2 = p^\alpha$. We also define R to be the gross rate of return (in terms of the second good) on k_j . Since both goods are freely traded and k_j is internationally mobile, all countries face the same p and R .

To obtain the competitive equilibrium of this world economy, we proceed in two steps. First, we solve the problem of a sequence of fictitious social planners who maximize the utility of the representative agent in each country. Second, we find the sequence of prices that clear international markets at each date.

The Social Planner's Problem

At every point in time, each country faces a resource constraint of the following form:

$$p \cdot (n_j - c_{1j}) + \pi_j \cdot k_j^\gamma - c_{2j} + R \cdot (1 - k_j) = 0 \quad (3)$$

Since output is not storable, Equation (3) simply ensures that all is consumed in all dates and states of the world. The social planner maximizes Equation (2) subject to this budget constraint. The solution to this problem is fully characterized by:

$$c_{1j} = \alpha \cdot p^{\alpha-1} \cdot c_j \quad (4)$$

$$c_{2j} = (1 - \alpha) \cdot p^\alpha \cdot c_j \quad (5)$$

$$1 - n_j = \frac{\beta}{1 - \beta} \cdot p^{\alpha-1} \cdot c_j \quad (6)$$

$$c_j = p^{1-\alpha} \cdot n_j + p^{-\alpha} \cdot (\pi_j \cdot k_j^\gamma + R \cdot (1 - k_j)) \quad (7)$$

$$k_j = \left(\frac{\gamma \cdot \pi_j}{R} \right)^{\frac{1}{1-\gamma}} \quad (8)$$

Equations (4)-(6) show the trade-offs between consumption of the two commodities and leisure in terms of aggregate consumption. The latter is given in Equation (7) and is equal to income, since we have assumed away savings. Equation (8) states that, in equilibrium, consumers equate the marginal product of mobile capital to the world's rate of return.

World Equilibrium Prices

To obtain the equilibrium rate of return on mobile capital, R , we can average (8) over all countries to find that $k = \left(\frac{\gamma \cdot \pi}{R} \right)^{\frac{1}{1-\gamma}}$, where $\pi = \frac{1}{J} \cdot \left(\sum_{j=1}^J \pi_j^{\frac{1}{1-\gamma}} \right)^{1-\gamma}$ is a measure of world's average productivity. Since the world's average stock of mobile capital is 1, it follows that the equilibrium rate of return on mobile capital is given by:

$$R = \gamma \cdot \pi \quad (9)$$

To obtain the equilibrium commodity prices, p , note that since all countries have the same consumption shares of both goods, it must be the case that $c_{1j}/c_{2j} = q_1/q_2$ for all j . Using Equations (6), (7), (8) and (9), we can again average over countries to find that the world average productions of commodity 1 and 2 are $q_1 = 1 - \beta \cdot \left(1 + \frac{\pi}{p} \right)$ and $q_2 = \pi$, respectively. Next, using (4) and (5) we obtain:

$$p = \frac{\alpha + \beta \cdot (1 - \alpha)}{(1 - \beta) \cdot (1 - \alpha)} \cdot \pi \quad (10)$$

Note that international productivity growth leads to increases in the relative price of commodity 1, which is the labour-intensive good. This is the first element of the transmission mechanism we outlined in the introduction. To see the second element, note that free trade and perfect competition ensure that the wage is equal to the price of the first good, $p^{1-\alpha}$, in all countries. Therefore, wage rates are equalized across countries and depend only on international commodity prices, and not on domestic factor endowments. In particular, we have that an increase in p raises the wage rate in all countries (this is nothing but the Stolper-Samuelson theorem).⁶

Data Analogs

Consistent with standard statistical practice, we define the GDP growth rate as the current value-weighted sum of the growth rates of each sector's production:

$$(1 - s_j) \cdot \frac{dq_{1j}}{q_{1j}} + s_j \cdot \frac{dq_{2j}}{q_{2j}} \quad (11)$$

where s_j is the value share of sector 2 in GDP at current prices.⁷ The Solow residual is that fraction of the GDP growth rate not accounted for by factor accumulation:

$$s_j \cdot \frac{d\pi_j}{\pi_j} \quad (12)$$

⁶ We could generate cross-country variation in wages by assuming labour-augmenting international productivity differences, as in Trefler (1993) or Ventura (1994). This would not alter our results, since domestic wages would still be determined by international commodity prices and not domestic factor endowments. This (and not that factor prices be equalized) is the key property of the model that we exploit here.

⁷ This is a chain-index measure of GDP. We both computed Figure 1 and solved the model using a chain-index and Laspeyres measures of GDP. We found that the choice of index neither substantially affects the correlations we reported in Figure 1, nor does it change the qualitative predictions of the model.

Since there is no savings in the model, the current account deficit is equal to the inflow of mobile capital. Expressing this inflow as a fraction of GDP, we obtain:

$$\frac{p_k \cdot dk_j}{q_j} \quad (13)$$

where p_k is the price of a unit of mobile capital.⁸

These definitions provide the linkage between model and data.

2. The International Transmission of Disturbances

The theory developed above can be used to illustrate how domestic and foreign shocks influence growth rates and the behavior of the current account. In this section, we derive the stochastic processes for the GDP growth rate and the current account for each country and discuss their properties. We start however by looking at the world economy as a whole.

World Aggregates

⁸ Given the nature of preferences and the assumptions of free trade and perfect competition, the price of a unit of mobile capital must equal the expected net present value of its marginal product, which is simply $p_k = \frac{p^{-\alpha} \cdot R}{\rho}$.

The first observation about world aggregates is that the world level of employment is constant. (To see this, note that $n=q_1$ and use Equation (10)). To understand this result, it is necessary to distinguish between two effects of productivity shocks on the consumer's labour supply decision. Consider an increase in π . Since the world production of good 2 has expanded, the relative price of good 1 increases, raising wages and therefore the opportunity cost of leisure. This tends to increase employment. At the same time, the increase in the world endowment of good 2 raises the level of income in the world. Those consumers who receive this additional income wish to use part of it to buy more leisure. This tends to reduce employment. In our special case of Cobb-Douglas preferences and permanent shocks, it turns out that these two effects cancel each other in the aggregate. Since none of the results that follow relies on the constancy of world employment, we retain this very convenient feature of the model as it delivers very simple solutions.⁹

An immediate implication of a constant aggregate level of employment is that world average GDP growth is fully accounted for by global Solow residuals (recall that the world average stocks of capital are also constant). Applying Ito's lemma to the world productivity index π (See Appendix A2), and letting g and SR denote the detrended GDP growth rate and Solow residual, respectively,¹⁰ we find that

$$g = SR = s \cdot \sigma \cdot \varepsilon \cdot d\omega \quad (14)$$

where $d\omega$ is a standard Wiener increment with $E[d\omega]=0$, $E[d\omega^2]=dt$ and $E[d\theta_j \cdot d\omega]=\varepsilon_j \cdot dt$ for all j . As shown in Appendix A2, the innovation in the world productivity index, $d\omega$, is a weighted average of the innovations in the country-

⁹ This result is related to the well-known difficulties of closed-economy models in generating large employment fluctuations when productivity shocks are permanent and the elasticity of substitution between labour and leisure is low.

¹⁰ As a result of non-linearities π exhibits a stochastic trend as Jensen's inequality becomes strict. Since this time trend is not very interesting, we present detrended growth rates throughout. In fact, the terms "growth rate" and "detrended growth rate" are used interchangeably in what follows.

specific productivity processes, $d\theta_j$. From the standpoint of country j , we will refer to the former as “foreign” shocks, and the latter as “domestic” shocks.

Domestic and Foreign Shocks as a Source of Fluctuations

The atomistic economies that populate our artificial world are subject to both domestic and foreign shocks. To disentangle the effects of both types of shocks and to understand how foreign shocks are transmitted to the domestic economy, we can write out the equilibrium stochastic processes for the (detrended) GDP growth rate in country j using Equations (6), (7), (8), (11) and (12) and applying Ito's lemma:

$$g_j = \left(1 + \frac{\gamma}{1-\gamma} - \beta\right) \cdot s_j \cdot \sigma \cdot d\theta_j + \left(\beta - \frac{\gamma}{1-\gamma}\right) \cdot s_j \cdot \sigma \cdot \varepsilon \cdot d\omega \quad (15)$$

A positive domestic productivity shock ($d\theta_j > 0$) has three effects on the growth rate. First, there is a direct effect which simply consists of the increased production in sector 2. Second, the domestic shock raises the marginal product of mobile capital and produces a capital inflow. The strength of this effect is measured by $\gamma/(1-\gamma)$. The higher is the share of mobile capital in production (γ), the larger is this capital inflow. Third, an increase in domestic productivity raises income at home and induces consumers to buy more leisure, thereby reducing employment. The force of this effect is measured by β , which is the parameter that captures how important leisure is for consumers. These effects work in opposite directions. The direct effect and the capital inflow raise output while the reduction in employment lowers it. Since $1/(1-\gamma) \geq \beta$, the model unambiguously predicts that positive domestic productivity shocks raise the growth rate.

A foreign positive productivity shock ($d\omega > 0$) has two effects on a country's growth rate. First, it raises the marginal product of capital abroad and produces a capital outflow. This is the interest-rate effect and its force is measured by $\gamma/(1-\gamma)$. In addition, the foreign shock raises the relative price of commodity 1 and, therefore, wages at home. This stimulates employment and output in the domestic economy. This is the wage effect and its strength is measured by β . For a foreign shock to raise the growth rate, the second effect must dominate, i.e. $\beta > \gamma/(1-\gamma)$. If this condition holds, international booms are positively transmitted into the domestic economy.

Using Equations (14) and (15), we can compute the instantaneous cross-country GDP growth correlation as follows:

$$\frac{\varepsilon}{\sqrt{\left(\frac{1}{1-\gamma} - \beta\right)^2 \cdot (1-\varepsilon^2) + \varepsilon^2}} \quad (16)$$

Since the stochastic process for country j 's Solow residual is $SR_j = s_j \cdot \sigma \cdot d\theta_j$ (combine Equations (1) and (12) to see this), it follows that the correlation coefficient between country j 's Solow residual and that of the world is ε . Clearly, this Solow residual correlation will be smaller than the GDP growth correlation in Equation (16) if $\beta > \gamma/(1-\gamma)$. Thus the model is qualitatively consistent with the empirical finding that most OECD countries are located in the upper quadrants of Figure 1, with GDP growth correlations exceeding those of Solow residuals.

Admittedly, our model is too stylized to bring to the data in its present form. Serious empirical analysis would require us first to remove some of the restrictions we have imposed on preferences, technology and the structure of productivity

shocks. Yet, it is still useful to gain a rough idea of the size of the GDP growth correlations predicted by the model. Since on average the cross-country correlation of Solow residuals is .37 (see Table 1), let $\epsilon=0.37$. Since empirical estimates of the labour-supply elasticity range from 0.05 to 0.20, and since the share of labour in output, $(1-s_j)$, ranges from 1/3 to 2/3, it is reasonable to think of β as belonging to the interval $(0.025, 0.4)$ (Equation (6) implies that this elasticity is $\beta \cdot (1-s_j)/s_j$). Finally, the share of capital that is mobile, γ , is likely to be very small. If we think of internationally mobile capital as being machinery and equipment, this typically accounts for about half of the private manufacturing capital stock. When we include land, public capital and infrastructure in the total capital stock, it is plausible that the share of mobile capital be less than 0.2. Therefore, we use values of γ in the interval $(0.05, 0.2)$. If we make the interest-rate effect small ($\gamma=0.05$) and the wage effect large ($\beta=0.4$), the model delivers a value for the GDP growth correlation of 0.52. If we make the interest-rate effect large ($\gamma=0.2$) and wage-effect small ($\beta=0.025$), we find that the predicted GDP correlation is 0.31. Therefore, the observed GDP growth correlation of 0.45 falls within the range predicted by the model.

Current Account Dynamics

Consider next the stochastic process for the current account. Using (8) and (13) and applying Ito's lemma, we obtain:

$$ca_j = \frac{-\gamma^2}{(1-\gamma)} \cdot \frac{1}{\rho} \cdot \frac{\pi}{\pi_j} \cdot s_j \cdot \sigma \cdot (d\theta_j - \epsilon \cdot d\omega) \quad (17)$$

Not surprisingly, positive domestic productivity shocks lead to current account deficits as capital flows into the economy. Also, positive foreign productivity shocks lead to current account surpluses as capital flows out of the economy. Whether the economy experiences a current account deficit or surplus depends upon whether the domestic shock is larger or smaller than the foreign shock.¹¹ Using Equations (14), (15) and (17), we can also compute the correlation of the current account surplus with the deviation of a country's GDP growth from world average GDP growth, i.e. the quantity we plotted in the X-axis of Figure 1:

$$\frac{-\frac{1}{1-\gamma} + \beta}{\sqrt{\left(\frac{1}{1-\gamma} - \beta\right)^2 + \left(1 - \frac{s}{s_j}\right)^2 \cdot \frac{\varepsilon^2}{1-\varepsilon^2}}} \quad (18)$$

Since this expression is always negative, the model is qualitatively consistent with the pattern of current account correlations that we report in Figure 1. However, this correlation coefficient averages -0.1 in the data and the model predicts it to be -1 for the typical economy ($s_j=s$).¹² This quantitative discrepancy between the model and the data clearly indicates that there are important sources of uncertainty in real economies other than those considered here. For instance, productivity shocks in the labour-intensive sector which are uncorrelated across countries would reduce these correlations, without eliminating the wage effect that explains the positive transmission of fluctuations across countries. Since our purpose is to clarify

¹¹ Traditionally, the empirical literature on the current account emphasized the distinctions between permanent/transitory and anticipated/unanticipated shocks. Recently, some authors have recognized that the distinction between global and country-specific shocks might be crucial in understanding current account dynamics. See Razin (1993) and Glick and Rogoff (1995), for instance. Our work clearly relates to these recent papers. For instance, the expression inside the brackets in (17) is the idiosyncratic component of country j 's productivity growth, defined as the residual from a regression of country j 's productivity growth rate on world average productivity growth. Therefore, (17) provides a theoretical underpinning for the specification for the current account estimated by Glick and Rogoff.

¹² Since the ratio s/s_j ranges from 0.5 to 2 in the data, we could at most lower this predicted current account correlation to 0.86 (using $s/s_j=2$, $\beta=0.4$ and $\gamma=0.05$).

the theoretical properties of the transmission mechanism and not to provide an empirical model ready to face the data, we omit these complications here.

3. Financial Integration

During most of the sample period from 1965 to 1990 which we study, financial markets have been geographically segmented. Recently, however, there have been significant reductions in the legal and technological obstacles to international trade in financial assets. In this section of the paper, we present a second model of trade and fluctuations in which the residents of some countries are also allowed to trade in financial assets. Somewhat surprisingly, the model predicts that financial integration weakens the transmission mechanism, reducing the synchronization of economic fluctuations across countries.

A Model of Financial Integration

Suppose that a fraction λ of all countries allow their residents to freely trade contingent claims among themselves. Without loss of generality, order countries so that the first $\lambda \cdot J$ countries are financially integrated (we ignore integer constraints). We assume that financial markets are complete in the Arrow-Debreu sense.

For given world prices, R and p , the competitive equilibrium for the set of financially integrated countries coincides with the solution to the social planner's problem of maximizing:

$$\sum_{j=1}^{\lambda \cdot J} \phi_j \cdot E_0 \int_0^{\infty} \ln \left\{ \left(c_{1j}^{\alpha} \cdot c_{2j}^{1-\alpha} \right)^{1-\beta} \cdot (1-n_j)^{\beta} \right\} \cdot e^{-\rho \cdot t} \cdot dt \quad (19)$$

subject to a collection of aggregate resource constraints of this form:

$$\sum_{j=1}^{\lambda \cdot J} p \cdot (n_j - c_{1j}) + \pi_j \cdot k_j^\gamma - c_{2j} + R \cdot (1 - k_j) = 0 \quad (20)$$

Note that by varying the initial distribution of the country weights, ϕ_j , we are varying the relative wealth of each country at the time of financial integration. In our case of homothetic preferences (as defined over state-contingent and dated commodities), it is possible to show that, if we normalize $\sum_{j=1}^{\lambda \cdot J} \phi_j = 1$, the weight ϕ_j is the relative wealth (expected NPV of income) of country j at any given date or state of nature.

There is a unique interior solution to the social planner's problem. Equations (4)-(6) and (8) still describe the optimal consumption, investment and labour supply decisions, but Equation (7) has to be replaced by:

$$c_j = \phi_j \cdot \frac{1}{\lambda \cdot J} \cdot \sum_{j=1}^{\lambda \cdot J} p^{1-\alpha} \cdot n_j + p^{-\alpha} \cdot (\pi_j \cdot k_j^\gamma + R \cdot (1 - k_j)) \quad (21)$$

This equation shows that in a world of complete markets (and homothetic preferences), countries will share aggregate consumption according to their relative wealth.

To complete the solution of the model, we compute the world equilibrium values for R and p . Since Equation (8) holds for all countries, we can follow the arguments in Section 3 to determine that R is still given by Equation (9). Similarly, we can follow earlier arguments to reach the conclusion that (10) still determines the equilibrium relative prices, p .

Financial Integration and the Transmission Mechanism

We can now examine the effects of financial integration on the pattern of cross-country GDP growth correlations.¹³ Following the procedures of Section 3, we can write the equilibrium stochastic processes for the growth rate of a financially integrated country as follows:¹⁴

$$g_j = \left(1 + \frac{\gamma}{1-\gamma}\right) \cdot s_j \cdot \sigma \cdot d\theta_j - \frac{\gamma}{1-\gamma} \cdot s_j \cdot \sigma \cdot \varepsilon \cdot d\omega \quad (22)$$

Note that this expression is the same as the growth rate of output in Equation (15), but with the labour share parameter β set to zero. Equation (22) shows that now foreign shocks ($d\omega$) are negatively transmitted to the domestic economy. In fact, the cross-country GDP growth correlation is:

$$\frac{\varepsilon}{\sqrt{\left(\frac{1}{1-\gamma}\right)^2 \cdot (1-\varepsilon^2) + \varepsilon^2}} \quad (23)$$

¹³ We do not discuss further the implications for current account dynamics, as these are the same for all countries. To see this, note that all countries spend the same share of their wealth on any subset of commodities (a property of homothetic preferences). It follows that all countries choose to spend the same fraction of their wealth in any date and therefore exhibit identical rates of wealth accumulation. Since storage is not possible, savings must equal zero for the set of financially integrated economies, and hence for each of them individually. Therefore, the current account deficit is still equal to net foreign investment. The latter behaves identically in all countries of the world, regardless of whether they permit trade in financial assets or not (See Equation (8)).

¹⁴ To compute this growth rate, we need to know the properties of $\pi_\lambda = \frac{1}{\lambda \cdot J} \cdot \left(\sum_{i=1}^{J-1} \pi_i^{\frac{1}{1-\gamma}} \right)^{1-\gamma}$, which is a

measure of the productivity of the integrated economies. Applying Ito's lemma to π_λ we find that $d\pi_\lambda/\pi_\lambda - E(d\pi_\lambda/\pi_\lambda) = \varepsilon \cdot d\omega$ (see Appendix A2). Observe that the (detrended) growth rates of the productivity indexes of the integrated economies and the whole world are perfectly correlated. Since there are infinitely many integrated economies, the average of these economies behaves just as the average of the infinitely many economies in the world as a whole.

which is less than ε since $\gamma > 0$. That is, financially integrated economies exhibit GDP growth correlations which are smaller than those of Solow residuals. This model therefore predicts that financial integration reduces the degree of synchronization of business cycles, and that one should expect countries to fall somewhere in the lower-left quadrant of Figure 1 as financial integration becomes more prevalent.

The intuition for this surprising result is quite simple: In financially integrated countries, international booms not only produce the interest-rate and wage effects, but they also raise domestic income since the home economy shares in the good times experienced by the rest of the world through financial risk-sharing agreements. This risk-sharing effect induces agents to buy more leisure, thereby reducing employment. In our stylized model, this risk-sharing effect on employment exactly cancels out the wage effect. Since we still have the capital outflow that a foreign boom creates, GDP growth correlations fall below those of Solow residuals.

It should be apparent that the existence of a risk-sharing effect is a robust result, since it will apply to any model in which the labour supply decision is affected by the level of income (that is, for any reasonable utility function excluding the quasilinear case). What is not robust here, however, is the result that the risk-sharing effect exactly offsets the wage effect. This is a special property of combining Cobb-Douglas preferences with permanent shocks. If either of these two restrictions is relaxed, there is no reason to expect the two effects to cancel each other. For instance, by choosing preferences with a high (low) elasticity of substitution between leisure and consumption, we would make the wage effect large (small), without altering the size of the risk-sharing effect.¹⁵ Also, by assuming that shocks are transitory and/or anticipated (so that they can be 'smoothed' over time),

¹⁵ The CES utility function works nicely in this regard.

we would make risk-sharing effects small, without altering the size of the wage effect.^{16,17}

The U.S. states provide a natural experiment for our model of financial integration, since they constitute a set of integrated economies within the OECD.¹⁸ We can therefore use existing state-level data to help us quantify the importance of this risk-sharing effect. Figure 3 plots the correlation of a state Solow residual with the OECD Solow residual against the correlation of the same state gross state product (GSP) growth with the OECD GDP growth rate, during the 1970-1986 period for which we have data. The principal fact which emerges from this picture is that GSP correlations exceed Solow residual correlations in all but 3 states. We interpret this finding as an indication that the risk-sharing effect is small relative to the wage effect.

¹⁶ In this case, either a storage technology or a capital stock that lasts more than one period should be included in the model in order to allow agents to smooth the effects of productivity shocks over time. If not, making shocks transitory and/or anticipated would only lead to fluctuations in the interest rate.

¹⁷ However, empirical tests for unit roots in various measures of productivity disturbances indicate that these productivity measures are highly persistent or, equivalently, that Solow residuals are uncorrelated over time. See, for instance, Razin (1993) or Glick and Rogoff (1995).

¹⁸ This approach has been taken by Atkeson and Bayoumi (1993). Obstfeld (1993) and Lewis (1995) have examined the implications of financial market integration among countries, using various proxies to control for financial integration.

4. Concluding Remarks

We have developed a highly stylized model of commodity trade and economic fluctuations that illustrates how economic disturbances are positively transmitted internationally, generating the high degree of synchronization in GDP growth rates that OECD countries have exhibited during the 1965-1990 period. The positive transmission mechanism highlighted here is simple: International booms increase the prices of labour-intensive commodities, raising domestic wages and stimulating employment and output at home. This we label the *wage effect*. Empirically, this wage effect seems to be large enough to dominate the *interest rate effect*, which consists of the fact that international booms increase world interest rates, inducing agents to invest abroad, reducing the domestic capital stock and output. While smaller than the wage effect, this latter mechanism of negative transmission is still important since it generates predictions that are consistent with existing evidence on current account fluctuations in the OECD. In particular, the model correctly predicts that capital should flow into those countries that experience a boom (relative to the rest of the world), producing current account deficits.

The 1980s and early 1990s have brought about a rapid process of financial liberalization. To analyze the implications of this process for the transmission mechanism, we constructed a second model of trade and fluctuations in which agents in some countries are allowed to trade financial assets across borders. This model yields the counterintuitive prediction that the current process of financial integration should lead to a lower degree of synchronization of economic fluctuations. While the wage and interest rate effects still operate in the second model, financial integration creates an additional transmission channel: the *risk-sharing effect*. Since the domestic economy shares in the good times experienced in the rest of the world through financial risk-sharing agreements, international

booms raise income at home and, provided leisure is a normal good, discourage employment and reduce output. This is a mechanism of negative transmission and reduces the predicted cross-country GDP growth correlations. Although theoretically interesting, evidence from the U.S. states suggests that this risk-sharing effect is small relative to the wage effect.

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Appendix

A1 Data

Our measure of output, q_{jt} , is real GDP per capita in 1985 international prices using the Chain Rule index (RGDPC) from the Summers and Heston Penn World Tables Mark 5.6. We construct per capita Solow residuals as usual, i.e.

$$SR_{jt} = \Delta \ln q_{jt} - (1 - s_j) \cdot \Delta \ln L_{jt} - s_j \cdot \Delta \ln k_{jt}$$

where L_{jt} is total civilian employment in country j at time t , drawn from the OECD Yearbook of Employment Statistics; K_{jt} is the total capital stock from Summers and Heston (KAPW*POP); and $(1-s_j)$ is the labour share in GDP and is calculated as the share of wages in gross domestic expenditure, averaged over the period from 1965 to 1990, as reported by the OECD's national income accounts. World averages are constructed as the population-weighted averages of the corresponding per capita variables. The current account is expressed as a fraction of GDP, and is available from 1970 only, since data on GNP relative to GDP (RGNP) used to construct net factor payments are available only from this date in the Summers-Heston database.

The sectoral data referred to in Figure 2 are drawn from the United Nations Industrial Development Organization (UNIDO) data base. For each of the 28 three-digit ISIC sectors, labour intensity is measured as the share of wage payments in value added. Growth in real product prices is measured as the growth rate in the nominal value of production, less the growth rate of the corresponding output index, less the consumer price index. ISIC three-digit codes are given below in Table A1.

The Solow residual and gross state product (GSP) correlations for US states in Figure 3 are computed using GSP and employment data from the Bureau of Economic Analysis (BEA). Since we do not have any data on state-level capital stocks, state Solow residuals are constructed controlling only for labour inputs (using a labour share parameter of 0.6), and we report the correlations of these state Solow residuals with a world Solow residual constructed in the same manner.

Table A1: Three-Digit ISIC Manufacturing Codes

311	Food Products
313	Beverages
314	Tobacco
321	Textiles
322	Wearing Apparel, Except Footwear
323	Leather Products
324	Footwear, Except Rubber or Plastic
331	Wood Products, Except Furniture
332	Furniture, Except Metal
341	Paper Products
342	Printing and Publishing
351	Industrial Chemicals
352	Other Chemicals
353	Petroleum Refineries
354	Miscellaneous Petroleum and Coal Products
355	Rubber Products
356	Plastic Products
361	Pottery, China, Earthenware
362	Glass Products
369	Other Non-Metallic Mineral Products
371	Iron and Steel
372	Non-Ferrous Metals
381	Fabricated Metal Products
382	Machinery, Except Electrical
383	Machinery, Electric
384	Transport Equipment
385	Professional and Scientific Equipment
390	Other Manufactured Products

A2 Dynamics of Aggregate Productivity Indices

In this appendix we derive the dynamics of the world productivity index, π , and the productivity index of the integrated economies, π_i . Consider first the world productivity index, π . Applying Ito's lemma to π we obtain

$$\frac{d\pi}{\pi} - E\left[\frac{d\pi}{\pi}\right] = \frac{\sigma}{J} \cdot \sum_{j=1}^J \left(\frac{\pi_j}{\pi}\right)^{1/(1-\gamma)} \cdot d\theta_j = \sigma \cdot \varepsilon \cdot d\omega$$

where $d\omega \equiv (\varepsilon \cdot J)^{-1} \sum_{j=1}^J \left(\frac{\pi_j}{\pi}\right)^{1/(1-\gamma)} \cdot d\theta_j$. In the remainder of this appendix, we derive the properties of $d\omega$.

We first note that it is straightforward to verify that $E[d\omega]=0$ and that $E[d\theta_j \cdot d\omega] = \varepsilon \cdot dt$. The instantaneous variance of $d\omega$ is given by

$$E[d\omega^2] = 1 + \left(\frac{1-\varepsilon^2}{\varepsilon^2}\right) \cdot \frac{1}{J^2} \cdot \sum_{j=1}^J E\left[\left(\frac{\pi_j}{\pi}\right)^{2/(1-\gamma)}\right]$$

where we have applied the law of iterated expectations to take expectations conditional on the π_j 's. We now show that, conditional on the initial distribution of the endowments, the limit as $J \rightarrow \infty$ of the second term is zero at every time t . To do this, note first that we can exploit the standard inequality between geometric and arithmetic means (i.e. $\frac{1}{J} \sum_{j=1}^J \pi_j^{1/(1-\gamma)} \geq \left(\prod_{j=1}^J \pi_j^{1/(1-\gamma)}\right)^{1/J}$) to obtain the following bound:

$$E\left[\left(\frac{\pi_{jt}}{\pi_t}\right)^{2/(1-\gamma)} \middle| I_0\right] \leq E\left[\pi_{jt}^{2/(1-\gamma)} \cdot \left(\prod_{j=1}^J \pi_{jt}^{1/(1-\gamma)}\right)^{-2/J} \middle| I_0\right]$$

where I_0 denotes the information set available at time zero and we have explicitly introduced the time index in the productivity process. Next note that since the productivity disturbances follow a geometric Brownian motion, we can write $\pi_{jt} = \pi_{j0} \cdot \exp(\sigma \cdot \theta_{jt})$, where θ_{jt} is a normal random variable with mean zero and variance t . Substituting this into the above expression and rearranging yields

$$E \left[\left(\frac{\pi_{jt}}{\pi_t} \right)^{2/(1-\gamma)} \middle| I_0 \right] \leq \pi_{j0}^{2/(1-\gamma)} \cdot \prod_{j=1}^J \pi_{j0}^{-2/(1-\gamma)} \cdot E \left[\exp \left\{ \frac{2 \cdot \sigma}{1-\gamma} \cdot \left(\theta_{jt} - \frac{1}{J} \sum_{j=1}^J \theta_{jt} \right) \right\} \right]$$

The object inside the round brackets inside the expectation is a normal random variable with mean zero and variance proportional to t , so by the properties of the normal moment generating function, the expectation on the right hand side simplifies to $\exp(O(t))$. Under the assumption that the initial distribution of productivity shocks is bounded, we can then write

$$\frac{1}{J^2} \cdot \sum_{j=1}^J E \left[(\pi_{jt} / \pi_t)^{2/(1-\gamma)} \right] \leq \frac{1}{J} \cdot K \cdot \exp(O(t))$$

Taking limits as $J \rightarrow \infty$ yields the result that $E[d\omega] = dt$.¹⁹

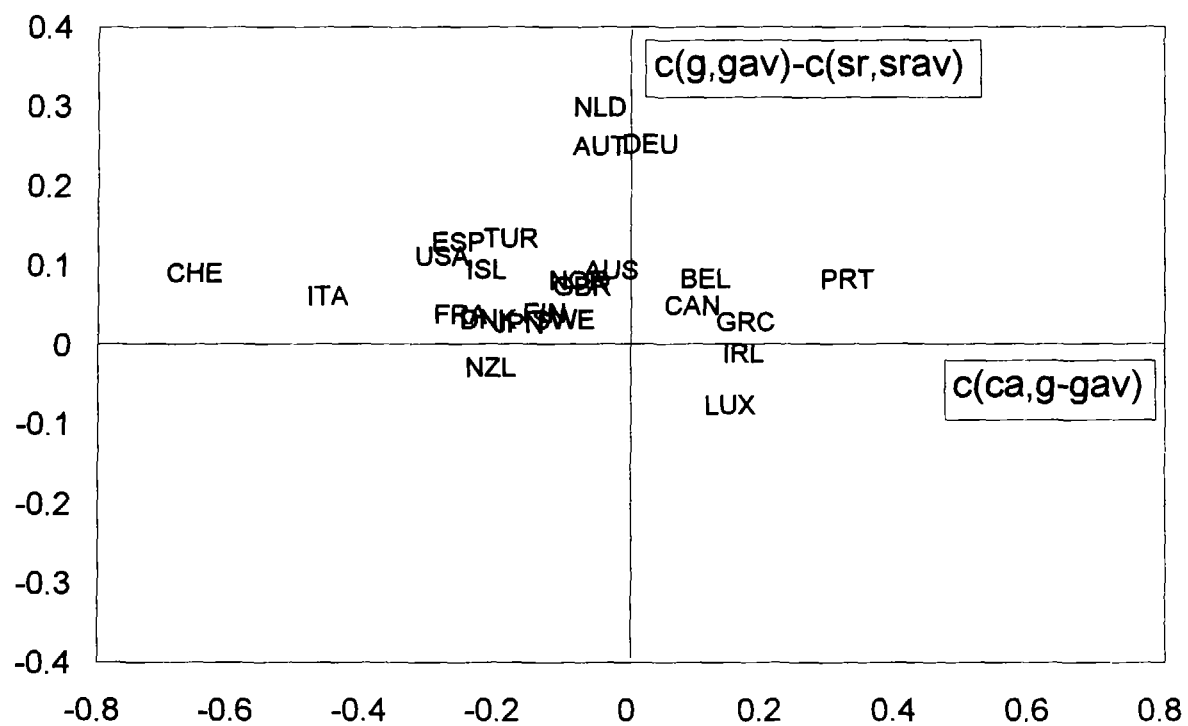
To obtain the dynamics of π_{λ} , we need only repeat the above arguments, replacing J with $\lambda \cdot J$. Thus we obtain that $d\pi_{\lambda} / \pi_{\lambda} = \sigma \cdot \varepsilon \cdot d\omega_{\lambda}$ with $E[d\omega_{\lambda}] = 0$ and $E[d\omega_{\lambda}^2] = 1$. Finally, we verify that $E[d\omega \cdot d\omega_{\lambda}] = 0$ so that we can set $d\omega = d\omega_{\lambda}$. Writing out the double sum in the multiplication of $d\omega$ and $d\omega_{\lambda}$, taking expectations and rearranging yields

$$E[d\omega \cdot d\omega_{\lambda}] = \lambda \cdot E[d\omega_{\lambda}^2] + \frac{(1-\lambda)}{\varepsilon^2 \cdot \lambda \cdot (1-\lambda) \cdot J^2} \cdot \sum_{j=1}^{\lambda \cdot J} \sum_{k=\lambda \cdot J}^J \left(\frac{\pi_{jt} \cdot \pi_{kt}}{\pi_t^2} \right)^{1/(1-\gamma)} E[d\theta_{jt} \cdot d\theta_{kt}] = 1$$

¹⁹ This is true for any fixed value of t . To encompass the limiting case as $t \rightarrow \infty$, we must impose the further, economically uninteresting condition that $J^{-1}(t) \exp(O(t)) = O(t^{-1})$.

as desired.

Figure 1: International Comovements



$C(g,gav)$ —Correlation between GDP growth and world average GDP growth, 1965-1990.

$C(sr,srav)$ —Correlation between Solow residual and world average Solow residual, 1965-1990.

$C(ca,g-gav)$ —Correlation between current account surplus (as a fraction of GDP) and deviation of output growth from world average output growth, 1970-1990.

Figure 2: Labour Intensity and the Cyclicity of Prices

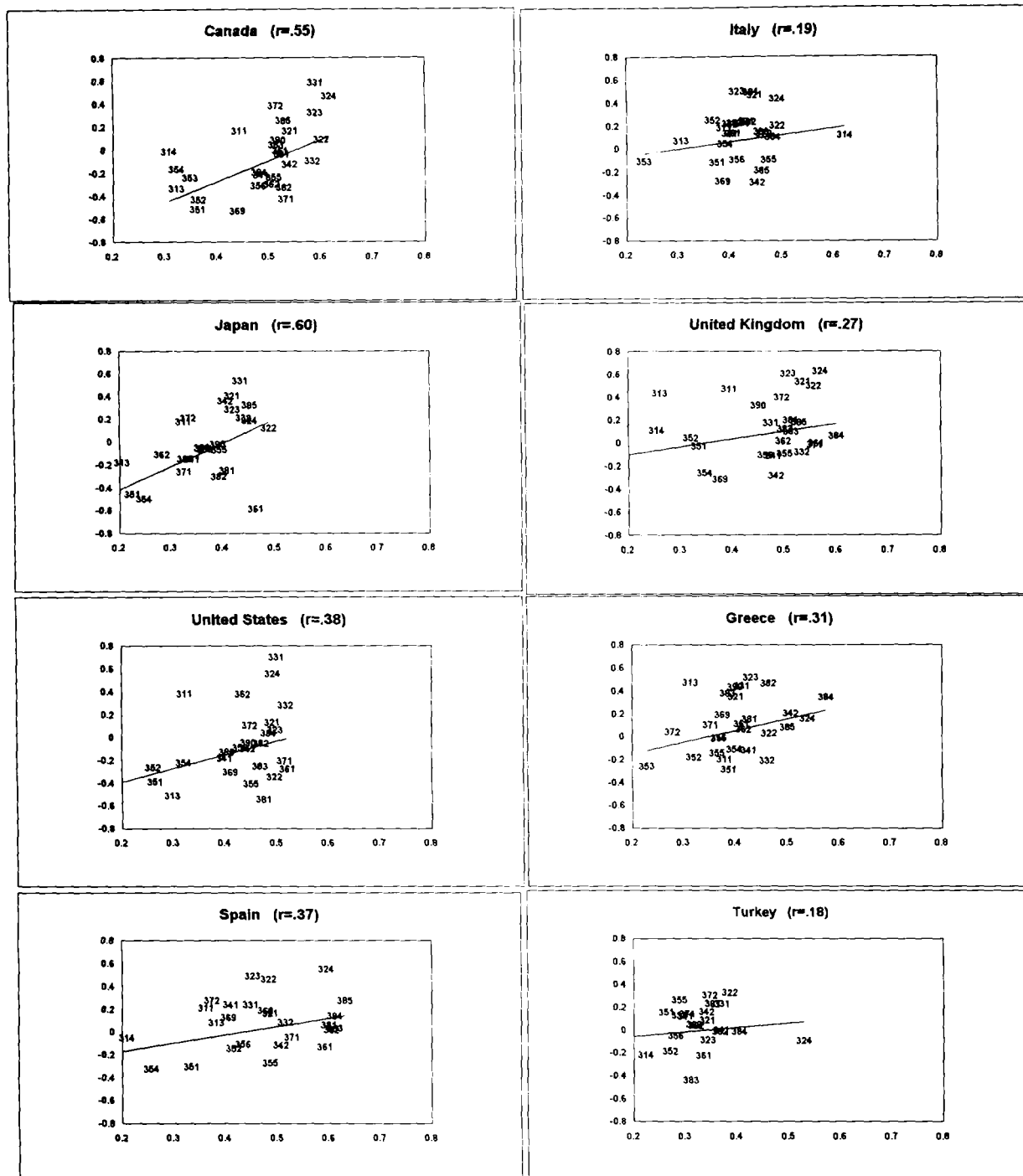
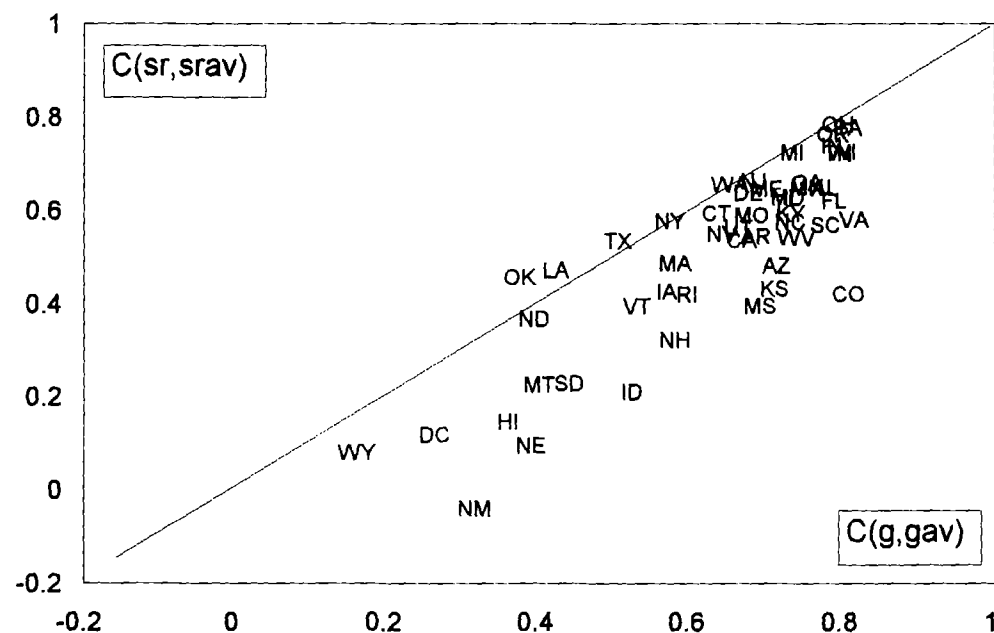


Figure plots the cyclicity of goods prices (vertical axis) against labour intensity of that good (horizontal axis) for 28 manufacturing sectors. Cyclicity of goods prices is defined as the correlation between the growth rate of each good's price with the growth rate of world average output over the period 1965-1990. Correlation between the cyclicity of prices and labour intensity for each country given in parentheses

Figure 3: Evidence From US States



$C(g, gav)$ —Correlation of GSP growth with world average GDP growth, 1970-1986.
 $C(sr, srav)$ —Correlation of Solow residual with world average Solow residual, 1970-1986.

Table 1: Stylized Facts on International Comovements

	(1) GDP	(2) CA	(3) Solow Residuals
AUS	0.61	-0.03	0.52
AUT	0.55	-0.05	0.30
BEL	0.52	0.11	0.44
CAN	0.70	0.09	0.65
DNK	0.56	-0.21	0.53
FIN	0.19	-0.13	0.15
FRA	0.65	-0.25	0.62
DEU	0.70	0.03	0.45
GRC	0.55	0.17	0.52
ISL	-0.01	-0.22	-0.11
IRL	0.35	0.17	0.36
ITA	0.55	-0.45	0.49
JPN	0.54	-0.17	0.51
LUX	0.51	0.15	0.58
NLD	0.67	-0.05	0.37
NZL	0.24	-0.21	0.26
NOR	0.20	-0.08	0.12
PRT	0.38	0.32	0.30
ESP	0.46	-0.26	0.33
SWE	0.20	-0.10	0.17
CHE	0.45	-0.65	0.36
TUR	-0.03	-0.18	-0.17
GBR	0.61	-0.07	0.54
USA	0.60	-0.28	0.49
Average	0.45	-0.10	0.37

(1) Contemporaneous correlation of GDP growth rate with world average GDP growth rate excluding that country, 1965-1990.

(2) Contemporaneous correlation of current account surplus with deviation of GDP growth rate from world average growth rate, 1970-1990.

(3) Contemporaneous correlation of Solow residual with world average Solow residual excluding that country, 1965-1990.

See Appendix A1 for a detailed description of the data.

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